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Lock and Hydro Machinery and Equipment Lubrication

Design Issues, Grease Lubrication, and Recent and Emerging Trends

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Outline of Presentation

- New EM 1424
- General Discussion – Lock and Dam and Hydro Machinery
- Operation and Maintenance
- Principles of Lubrication
- Essential Properties Grease
- Grease Requirements for Components

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New EM 1424

- Lubricants and Hydraulic Fluids
- Update of 1999 Manual
- Expected publish date November 2015
- Includes new and expanded chapters on EA lubricants and self lubricated materials
- Also separate chapters on open gears, greases, turbine oils, and hydraulic oils

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Machinery Lubrication - Trends

- Lubricants on USACE navigation and hydro structures have traditionally been mineral oil (petroleum) based. Recent trends have included utilizing more self -lubricated materials, synthetic based and environmentally acceptable lubricants.

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Operation and Maintenance Considerations

- Equipment varies across USACE and from lock site to lock site - many different operating environments
- Trial and error for lubricant selection
- Equipment goes through a range of temperatures, humidity, infrequency of use, and can be submerged during floods
- Variety of machinery - many open gears and gearboxes – hydraulic systems more common

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Machinery Lubrication Basics

- A lubricant is a substance that reduces friction, heat, and wear when introduced as a film between solid surfaces. Selecting and using the correct lubricant helps maximizes the life of bearings, gears, and machinery.
- Lubrication is also used to reduce oxidation and prevent rust; to provide insulation in transformer applications and to transmit mechanical power in hydraulic fluid power applications

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Lubrication Regimes

- The basic regimes of fluid film lubrication are:
- Hydrodynamic lubrication – two surfaces are separated by a fluid film – this is ideal!
- Elastohydrodynamic lubrication – two surfaces are separated by a very thin fluid film – related to rolling contact such as roller bearings
- Boundary lubrication – two surfaces mostly are in contact with each other even though a fluid is present

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Lubrication Principles

- Machinery will see boundary lubrication at start-up and shutdown (low speeds and thin film), before transition to hydrodynamic lubrication at normal operating conditions (high speeds and thick film).
- Many lock and dam and hydro components operate in the boundary lubrication regime – slow moving and high loads and intermittent use

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Open Gear Lubricants

- Open gears on navigation structures generally are very slow moving. These gears tend to be very large and are prone to contamination from dirt and debris. Any lubricant selection for open gears needs to be able to perform under adverse conditions including submersion.

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Open Gear Lubricants

- In open gear applications, the lubricant must resist being thrown off by centrifugal force or being scraped off by the action of the gear teeth. A highly adhesive lubricant is required for most open gear applications. Most open gear lubricants are heavy oils, asphalt-based compounds, or soft greases.

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Typical Machinery

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Components to Discuss

- Open Gears
- Wire Rope
- Chain
- Pintles
- Wicket Gates
- Typically grease lubricated

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Grease Basics

- Three components form grease
- Base Oil
- Thickener (soap)
- Additives
- Most greases produced today use mineral oil as base oil. In temperature extremes (low or high), a grease that utilizes a synthetic base oil will provide better stability.

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Grease Base Oil

- Base Oil can be mineral oil, synthetic, or bio-based (crop based)
- Synthetic base oils include Polyalpha Olefins (PAO), esters, and silicones
- EA synthetic greases are usually esters or PAO
- Bio-based oils include canola oil and rapeseed oil

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Grease Thickeners

- The thickener is a material that, in combination with the base oil, will produce the solid to semi-fluid structure. The primary type of thickener used in current grease is metallic soap. These soaps include lithium, aluminum, clay, polyurea, sodium, and calcium.
- Complex thickener-type greases are gaining popularity. They are being selected because of their high dropping points and excellent load-carrying abilities.

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Grease Additives

- Additives can play several roles in a lubricating grease. These primarily include enhancing the existing desirable properties, suppressing the existing undesirable properties, and imparting new properties. For USACE, one important consideration is Extreme Pressure additives for operation in boundary condition.
- The most common additives include:
    1) Oxidation
    2) Rust Inhibitors
    3) Extreme Pressure
    4) Antiwear
    5) Friction-reducing agents.

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Grease Properties

- The most important feature of a grease is its rigidity or consistency. Grease consistency depends on the type and amount of thickener used and the viscosity of its base oil. A grease's consistency is its resistance to deformation by an applied force. The measure of consistency is called penetration and is determined by ASTM D217 and D1403 methods.
- A penetration of 100 would represent a solid grease while a penetration of 450 would be semifluid. The NLGI has established consistency numbers or grade numbers, ranging from 000 to 6, corresponding to specified ranges of penetration numbers.

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NLGI Grease Ratings

NLGI#	ASTM - Worked Penetration	Food Analogy
000	4445-475	Ketchup
00	400-430	Applesauce
0	355-385	Brown Mustard
1	310-340	Tomato Paste
2	265-295	Peanut Butter
3	220-250	Vegetable Shortening
4	175-208	Frozen Yogurt
5	130-160	Smooth Paté
6	85-115	Cheddar Cheese Spread

NLGI 2 is most common

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Open Gear Grease

- Tackiness (adhesive/cohesive properties) – excellent adhesion to the gears
- Resistance to water washout and spray-off
- Load-carrying capability to protect against friction and wear
- Protection of the gears against wear and corrosion
- Cushioning ability (vibration reduction)
- Sprayability and/or ease of dispensability
- Resistance to fling-off
- No buildup in the roots of the gear teeth

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Other Grease Properties

- **Dropping point i**s an indicator of the heat resistance of grease. Temperature at which a grease becomes fluid enough to drip. The dropping point indicates the upper temperature limit at which a grease retains its structure, not the maximum temperature at which a grease may be used.
- **Oxidation stability** is the ability of a grease to resist a chemical union with oxygen. The reaction of grease with oxygen produces insoluble gum, sludges and lacquer-like deposits that cause sluggish operation, increased wear and reduction of clearances. Prolonged exposure to high temperatures accelerates oxidation in greases

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Grease Temperature Considerations

- **High-temperature effects.** High temperatures harm greases more than they harm oils. Grease cannot dissipate heat by convection like a circulating oil. Consequently, excessive temperatures result in accelerated oxidation or even carbonization where grease hardens or forms a crust.

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Low Temperature

- Low-temperature effects**.** If the temperature of a grease is lowered enough, it will become so viscous that it can be classified as a hard grease. Pumpability suffers and machinery operation may become impossible due to torque limitations and power requirements.
- As a guideline, the base oil's pour point is considered the low-temperature limit of a grease.
- Critical to consider for applications in low temperature climate

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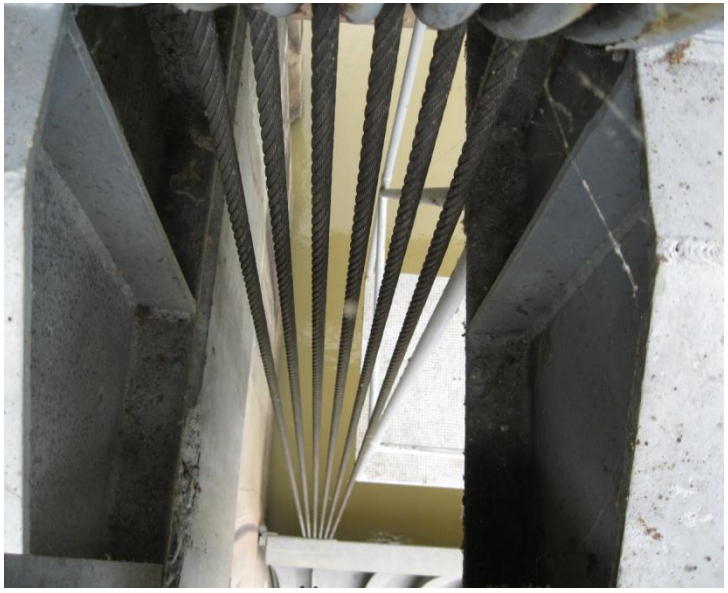
Wire Rope

- Wire rope lubrication serves two purposes. It is done primarily to prevent corrosion of carbon steel wire ropes. Wire rope lubrication also helps to prevent abrasion damage of the ropes as they pass through sheaves or wrap on drums. Because of this, stainless steel wire rope should be lubricated on a regular basis similar to galvanized wire rope.



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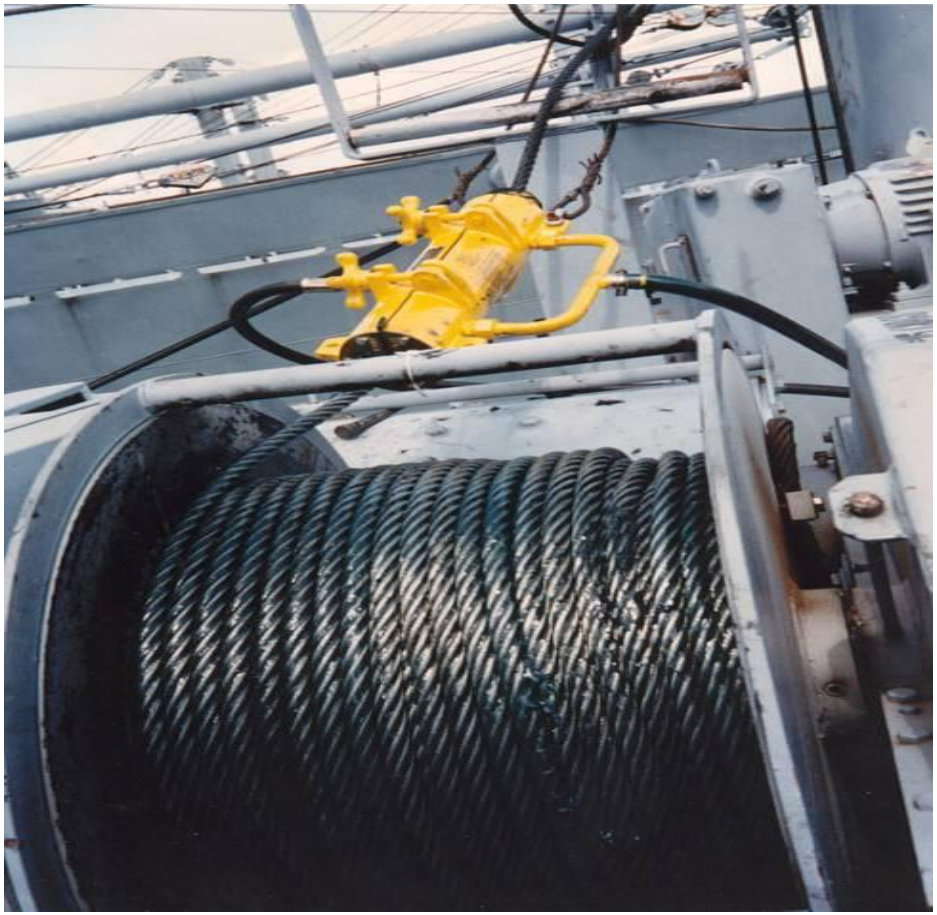
Wire Rope



Wire rope lubrication can be applied manually to surface of wire rope, sprayed on wire rope or applied with pressurized lubricator

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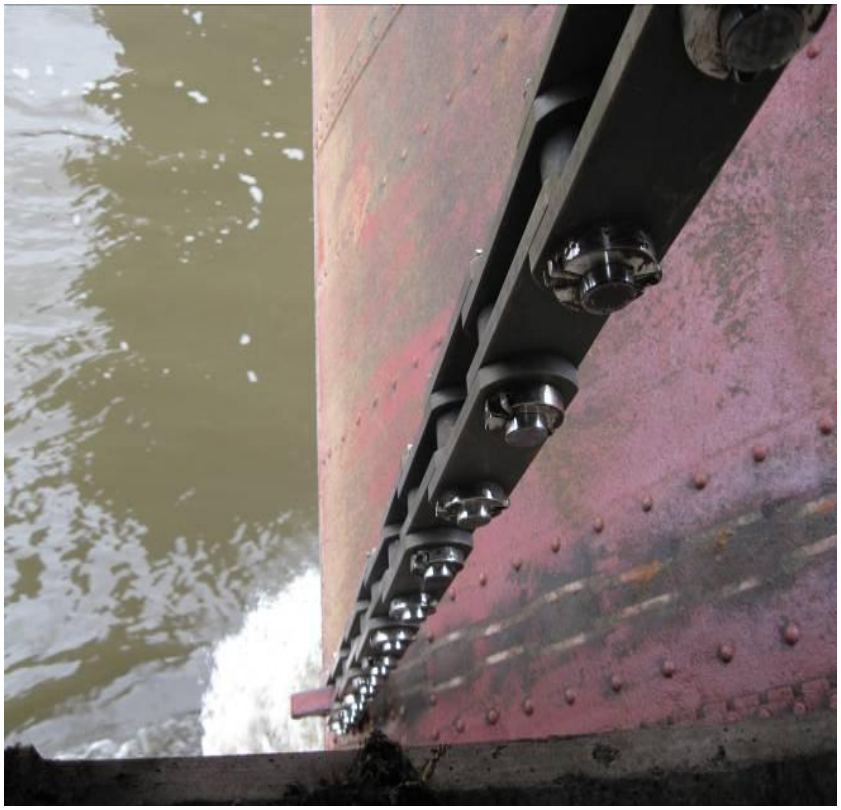
Chain



Roller chain with aluminum bronze sidebars and stainless steel pins has been used successfully. This eliminates greasing requirements. Design requirements for this type of chain are given in EM 1110-2-2610.

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Miter Gate and Sector Gate Pintles

Pintles support the weight of the gate. Includes sector gates and miter gates. Material has typically been bronze with grease lubrication required. Recent designs have utilized self lubricated bearings. Design requirements for this type of chain are given in EM 1110-2-2610.

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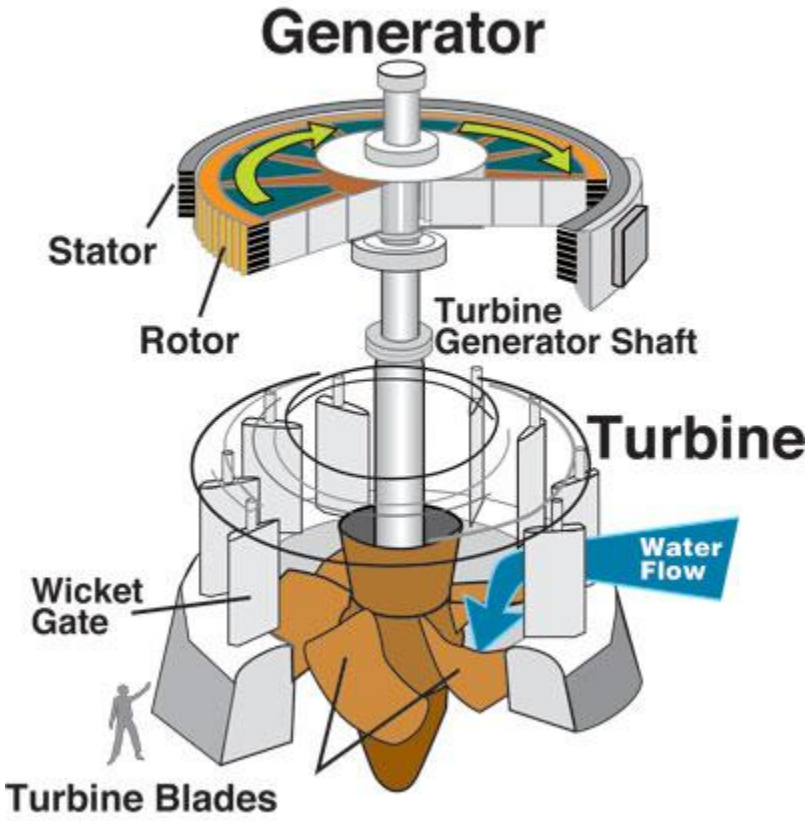
Wicket Gates



The wicket gate in hydroelectric dams is used to control the amount of water flowing from the penstock (essentially an intake tunnel) through the turbine.

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Wicket Gates

- Wicket gates have two or three journal bearings and one thrust bearing or collar per gate. The journal bearings resist the hydrostatic and hydrodynamic loads involved in regulating the flow of water into the turbine
- Even when shaft seals are provided, the grease can come into contact with water. In the worst cases, water can wash the lubricant out of the bearings

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Wicket Gates

- Traditionally, wicket gate bearings have been lubricated with a mineral oil, lithium-based, EP NLGI-2 grease.
- EA grease can provide an alternative
- Another way to reduce or eliminate the release of greases to the environment is to use self-lubricating bearings or bushings

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Questions?

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